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**GBA 2050627**
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**GB 1580105**
**GB 1398274**
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# (54) Fluid flow meters using Wiegand effect devices

(57) A single bar magnet 18 is mounted at one end of a paddle wheel impeller 14 of a tangential flow hydraulic fluid indicator. A Wiegand effect module 23 is located in a recess 24 formed in an outer surface of the casing. The module 23 is separated from the chamber 12 by a thin portion of the casing and the magnet 18 is located at the adjacent end of the impeller 14. The axis of rotation of the impeller 14 passes between the ends of the magnet 18. The Wiegand effect device is orientated so as to be substantially parallel to the plane of rotation of the bar magnet 18 so that the changes in the flux conditions in the Wiegand effect device caused by rotation of the magnet induce pulses in the sensing coil associated with the Wiegand effect device, the frequency of the pulses representing fluid flow.

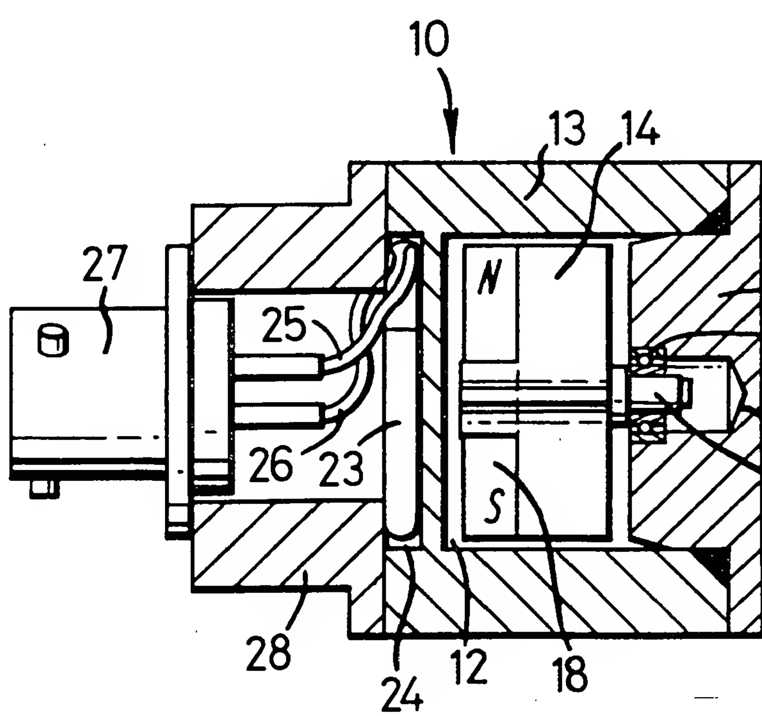


FIG.2

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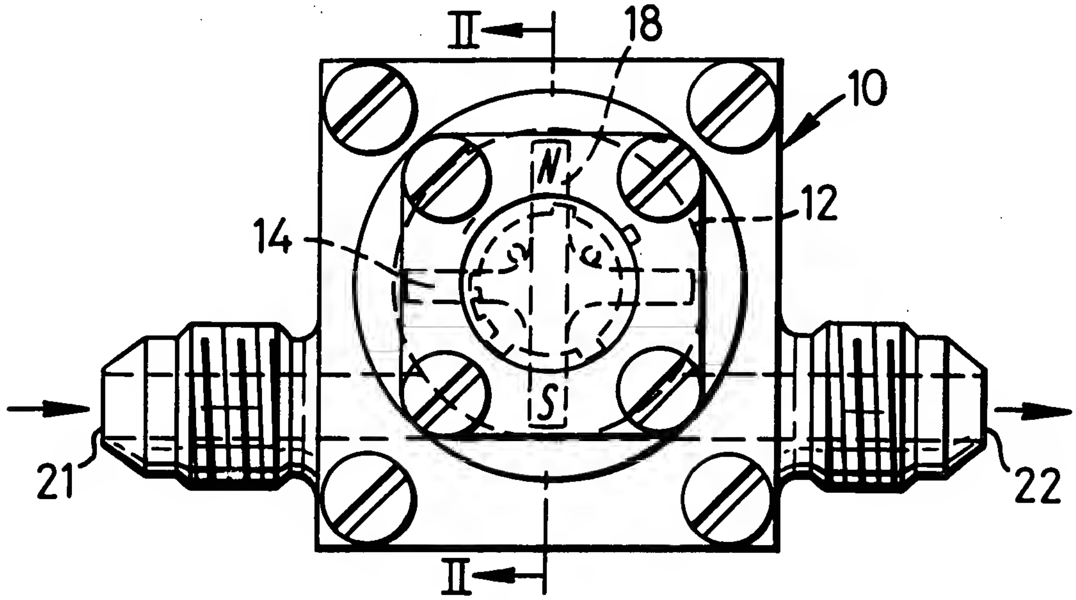
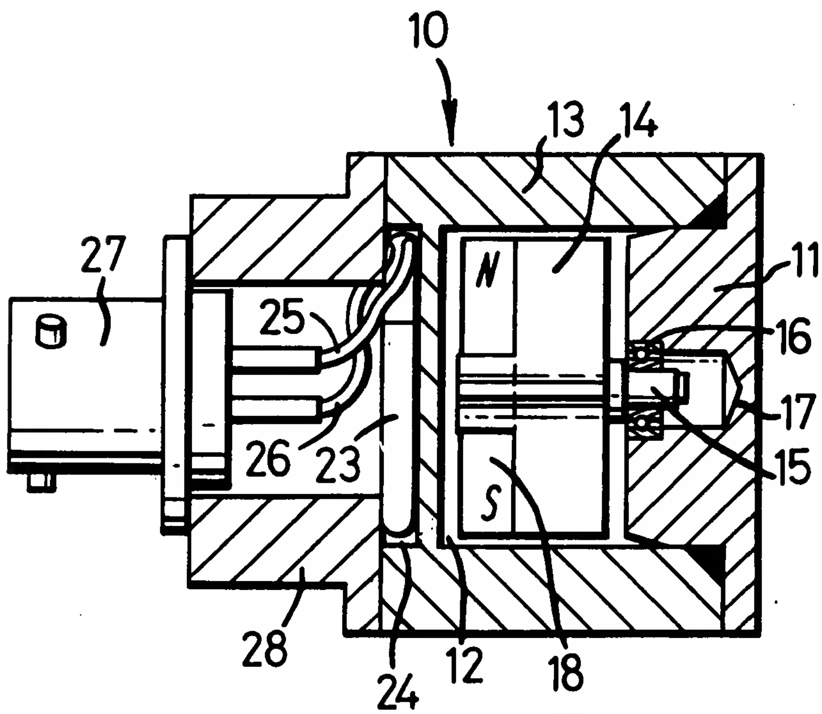


II
18
10
12
14
N
S
21
22
II


FIG.1



10
13
14
11
27
N
25
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17
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23
15
S
28
24
12
18


FIG.2

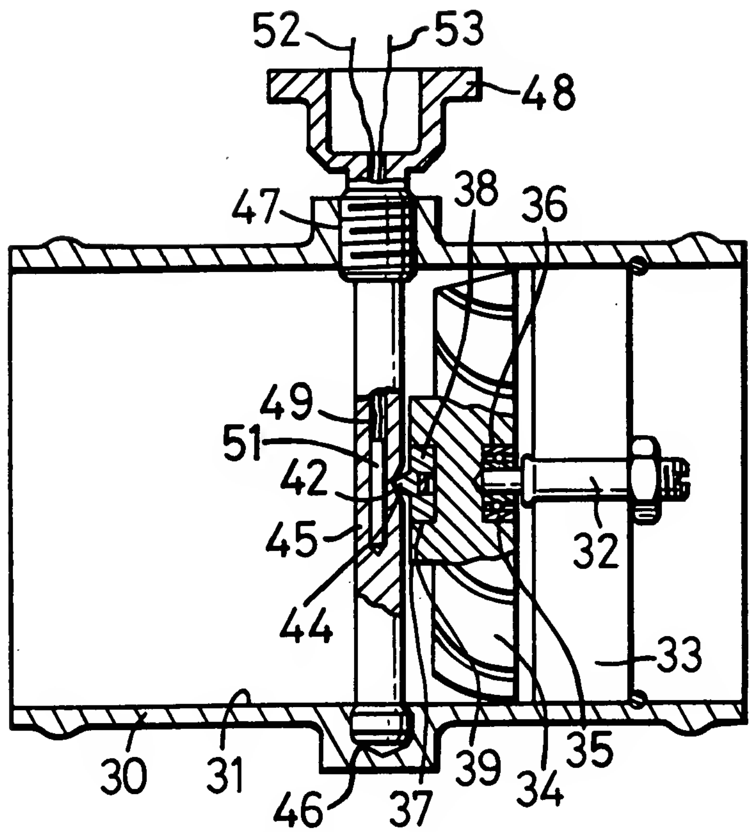

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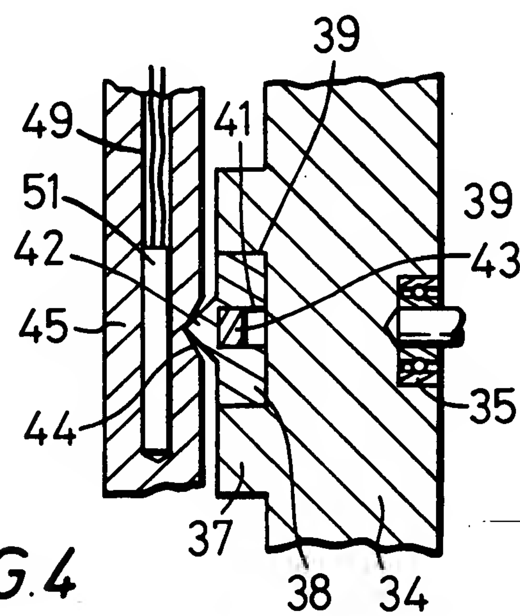
FIG.3



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49
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44
37
38
34


FIG.4

SPECIFICATION
**Fluid flow indicators**

This invention relates to fluid flow indicators in which an output signal indicative of the fluid flow rate is generated by the "so called" Wiegand effect.

A Wiegand effect device is a bi-stable magnetic device having two regions with different coercive forces which changes magnetic states with a rapid change in the flux conditions within it when subjected to a change in the strength and polarity of an applied magnetic field. A sensing coil is either wound around the device or placed near to the device so that each significant change in the flux conditions within the device in one sense induces a pulse in the coil. The recommended arrangement for flow measurement comprises a plurality of such Wiegand effect devices mounted on an impeller and each carried passed a static sensing coil and pair of oppositely polarized magnets by flow driven rotation of the impeller. The multiple pulses generated are proportional to the flow and the flow rate is determined by counting those pulses.

According to this invention there is provided a fluid flow indicator comprising a casing forming a fluid flow path and an impeller supported for rotation within said casing and located relative to said fluid flow path so as to be driven for rotation by fluid flow in said path, wherein one of either a single bar magnet or a single Wiegand effect device which is in the form of a length of wire, is mounted on the impeller such that it extends transversely with respect to the axis of rotation of the impeller which passes through it between its ends, and the other of the single bar magnet and the Wiegand effect device is mounted statically adjacent to a sensing coil and is orientated so as to be substantially parallel to the plane of rotation of said one of the single bar magnet and the Wiegand effect device, the relative location of the magnet, the Wiegand effect device and the sensing coil being such that relative rotation between the Wiegand effect device and the magnet effects significant changes in the flux conditions in the Wiegand effect device which in turn induce pulses in the sensing soil. The state of the single Wiegand effect device is changed to generate the output pulses that are counted to measure the fluid flow rate, by the use of one magnet only in contrast to the previously recommended arrangement which incorporates at least two oppositely polarized magnets.

Preferably the single bar magnet is mounted on the impeller and the sensing coil is wound around the Wiegand effect device.

The impeller of one form of fluid flow indicator in which this invention is embodied is a tangential flow impeller. The bar magnet may be mounted on an outer surface of the tangential flow impeller which may be a paddle wheel impeller. The bar magnet may be aligned with a diametrically opposed pair of paddle vanes of such a paddle wheel impeller. The length of the bar magnet may be equal to the diameter of a circular path traced by the radially outermost portion of the paddle vanes. Conveniently the Wiegand effect device and the sensing coil are located in a recess which is formed in the casing outside the fluid flow path.

The impeller of another form of fluid flow indicator in which this invention is embodied is an axial flow impeller. The bar magnet may be located within a cavity which is enclosed within the impeller adjacent one end of the impeller. The Wiegand effect device and the sensing coil may be housed in a hollow rod which extends across the flow path so that fluid flows around the portion of the rod in which the device and the coil are housed. The enclosed cavity may be formed between a main body of the impeller and an insert which is fitted into a recess in the main body portion, the insert forming a conical projection on its outer surface and that conical projection being seated within a complementary recess which is formed in the outer surface of the hollow rod whereby to locate the impeller radially, the apex of the conical projection lying on the axis of rotation of the impeller.

Two forms of hydraulic fluid flow indicator in which this invention is embodied will now be described by way of example with reference to the accompanying drawings, of which:—

Figure 1 is an end elevation of the indicator housing of one of the indicators which is for use in a computer based operational control system for an aircraft hydraulic control system;

Figure 2 is a section on the line II—II in Figure 1;

Figure 3 is a longitudinal section of the other form of indicator with parts shown in elevation for convenience; and

Figure 4 is a fragment of Figure 3 drawn to a larger scale.

The hydraulic fluid flow indicator 10 shown in Figures 1 and 2 comprises a casing of non-magnetizable material. The casing comprises an end cap 11 which is fitted in a fluid tight manner into one end of a circular chamber 12 which is formed in a rectangular body 13. The other end of the chamber 12 is closed by an end wall portion of the body 13.

A paddle wheel impeller 14 has a spindle 15 which is journalled at one end in a ball bearing 16 which is mounted in a recess 17 formed centrally in the end cap 11. Hence the impeller 14 is mounted coaxially in, and for rotation within the chamber 12. The impeller 14 has four paddle vanes which are arranged in mutually perpendicular diametrically opposed pairs (see Figure 1).

A bar magnet 18 is mounted on the outer surface of the impeller 14 adjacent the body end wall portion. The magnet 18 is aligned with one of the diametrically opposed pairs of vanes and thereby is orientated such that it is transverse to the axis of rotation of the impeller 14 which passes between its poles. The length of the bar magnet 18 is substantially equal to the distance between the outer ends of the two vanes of each

diametrically opposed pair. Hence the length of the bar magnet 18 is substantially equal to the diameter of an imaginary circular path which is traced by the radially outermost portion of the vanes.

An opposed pair of ports 21 and 22 are formed coaxially in the side walls of the body 13. The axis of the ports 21 and 22 is offset from the axis of the spindle 15. The ports 21 and 22 communicate with the chamber 12 and are adapted to connect the chamber 12 into a selected hydraulic fluid flow line of the hydraulic control system so that the impeller 14 is driven for rotation within the chamber 12 by a tangential flow of hydraulic fluid through that chamber 12. Hence the impeller 14 is a tangential flow impeller.

A Wiegand effect module 23 is located in a recess 24 formed in the surface of the body end wall portion that is further from the chamber 12. Hence the module 23 is located outside the hydraulic fluid flow path. The module 23 is elongate and is orientated such that it is substantially parallel to the plane of rotation of the bar magnet 18. It also is transverse to the axis of rotation of the impeller 14 which passes between its ends. The module 23 comprises a coil wound around a Wiegand wire element which is a bi-stable magnet device comprising a length of wire of magnetizable material having a hard shell and a softer inner core which are regions with different coercive forces. The ends of the coil are connected by leads 25 and 26 to a connector 27 which is fitted into one end of a bore of a tubular plug 28, the plug 28 being releasably mounted at its other end to the body 13 and thereby retaining the module 23 in position in the recess 24.

When the indicator 10 is used, the ports 21 and 22 are connected into the selected hydraulic fluid line of the hydraulic control system and the connector 28 is connected to a pulse counter of the computer based operational control system.

Fluid flow in the selected hydraulic line drives the impeller 14 so that it rotates. The magnet 18 rotates with the impeller relative to the wire element of the Wiegand effect module 23 from which it is separated by a thin portion of the body end wall. The magnetic polarity of the magnetic field of the magnet 18 in the region of the module 23 alternates across the module 23 with rotation of the magnet 18. The arrangement is such that the wire element is magnetized by the magnet 18 such that the direction of flux flow in both the shell and the core of the element is the same when the magnet 18 is in one of its two positions in which it is aligned with the module 23. The wire element is switched to its other state such that the direction of flux flow in the core is reversed relative to the direction of flux flow in the shell when the magnet 18 has rotated through 180° to the other of its two positions in which it is aligned with the module 23 and in which the location of its poles is reversed compared to those of said one position. The wire element is reset to said one state when the magnet 18 has rotated through a further 180° back to said one position. A pulse is induced in the sensing coil as the wire element is switched to said one state, that pulse terminating when the wire element is switched to the other state. The pulses are transmitted from the wire element to the pulse counter via the leads 25 and 26 and the connector 27 and they are proportional to the fluid flow through the chamber 12 that drives the impeller 14. The rate of fluid flow through the chamber 12 is determined by counting the pulses. The sensed fluid flow rate determined by the pulse counter is employed to provide a continuous signal when fluid flow is passing along the hydraulic line and to cease signalling when that flow has dropped below a predetermined minimum rate. In this way the flow indicator provides the computer based operational control system with information on the behaviour of fluid in the line so that the computer based operational control system can check that the hydraulic control system is behaving correctly or that a fault has occurred and can initiate corrective action.

Such a hydraulic fluid flow indicator which is arranged to be driven for rotation by a tangential fluid flow is suitable for use with small volume fluid flows. The limiting factor governing the range of fluid flows with which it is practical to use a tangential flow arrangement is the maximum size of the casing that can be tolerated. For higher volume flows, we prefer to use an axial flow impeller and a suitable arrangement is shown in Figures 3 and 4.

Figure 3 shows a tubular casing 30 which is open at either end. The casing 30 is provided with fittings at either end whereby it is connected into the fluid flow line so that its bore is a continuation of that flow line.

A static support shaft 32 is supported substantially coaxially within the bore 31 by a spider support 33. An axial flow impeller 34 is journalled on one end of the shaft 32 by a ball bearing 35 for rotation substantially coaxially within the bore 31, the ball bearing 35 being spigotted into a recess 36 which is formed at the centre of one end of the impeller 34. A boss 37 is formed at the centre of the other end of the impeller 34. The body of the impeller 34 is formed of non-magnetizable material. A circular insert 38 of non-magnetizable material is spigotted into a recess 39 which is formed at the centre of the boss 37. A diametral slot 41 is formed at the end of the insert 38 that abuts the base of the recess 39 and a conical projection 42 is formed by the other, outer end of the insert 38. A bar magnet 43 is fitted into the slot 41. Hence the bar magnet 43 is located in an enclosed cavity adjacent one end of the impeller 34. The axis of rotation of the impeller 34 passes through the centre of the slot 41, through the apex of the conical projection 42 and through the bar magnet 43 between its poles.

The conical projection 42 is seated in a conical recess 44 which is formed in the outer surface of a hollow cylindrical rod 45 which extends diametrically across the bore 31. The rod 45, which has one end located in a recess 46 in the

surface of the bore 31, extends through a tapped hole 47 which is formed in the tubular casing 30 opposite the recess 46, having a short screw threaded portion by which it is screwed into that tapped hole 47, and terminates in a flanged cup-shaped coupling piece 48 at its end outside the tubular casing 30. The hollow interior of the hollow rod 45 is formed by a small diameter axially extending blind bore 49 which extends from the cavity of the cup-shaped coupling piece 48, into which it opens, passed the conical recess 44 to its closed end which is located between the recess 46 and the axis of the bore 31, being spaced from that axis by more than half the length of the bar magnet 43.

An elongate Wiegand effect module 51 is located within the blind bore 49 at the closed end of that bore 49. The module 51 is similar to the module 23 of the indicator 10 described above. Also the relative orientation of the static module 51 and the rotatable bar magnet 43 is substantially the same as the relative orientation of the static module 23 and the rotatable bar magnet 18 of the indicator 10 that has been described above. Leads 52 and 53 are connected respectively to either end of the coil of the Wiegand effect module 51 and are led through the bore 49 to the cavity formed by the coupling piece 48 for connection by a suitable connector (not shown) into an associated operational control system.

Fluid flow through the bore 31 passes the static spider support 33 and the hollow rod 46 and drives the impeller 34 for rotation about its axis. The interaction of the rotating bar magnet 43 and the static Wiegand effect module 51 causes a series of pulses to be transmitted via the leads 52 and 53 in the same way as has been described above with reference to the bar magnet 18 and the Wiegand effect module 23 of the indicator 10. These pulses can be used in the same way to monitor the fluid flow.

CLAIMS

1. A fluid flow indicator comprising a casing forming a fluid flow path and an impeller supported for rotation within said casing and located relative to said fluid flow path so as to be driven for rotation by fluid flow in said path, wherein one of either a single bar magnet or a single Wiegand effect device which is in the form of a length of wire, is mounted on the impeller such that it extends transversely with respect to the axis of rotation of the impeller which passes through it between its ends, and the other of the single bar magnet and the Wiegand effect device is mounted statically adjacent to a sensing coil and is orientated so as to be substantially parallel to the plane of rotation of said one of the single bar magnet and the Wiegand effect device, the relative location of the magnet, the Wiegand effect device and the sensing coil being such that relative rotation between the Wiegand effect device and the magnet effects significant changes in the flux conditions in the Wiegand effect device which in turn induce pulses in the sensing coil.

2. A fluid flow indicator according to Claim 1, wherein the single bar magnet is mounted on the impeller and the sensing coil is wound around the Wiegand effect device.

3. A fluid flow indicator according to Claim 1 or Claim 2, wherein the impeller is a tangential flow impeller.

4. A fluid flow indicator according to Claim 3 when appended to Claim 2, wherein the bar magnet is mounted on an outer surface of the impeller.

5. A fluid flow indicator according to Claim 4, wherein the impeller is a paddle wheel impeller and the bar magnet is aligned with a diametrically opposed pair of paddle vanes of the paddle wheel impeller.

6. A fluid flow indicator according to Claim 5, wherein the length of the bar magnet is equal to the diameter of a circular path traced by the radially outermost portion of the paddle vanes.

7. A fluid flow indicator according to any one of Claims 3 to 6 when appended to Claim 2, wherein the Wiegand effect device and the sensing coil are located in a recess which is formed in the casing outside the fluid flow path.

8. A fluid flow indicator according to Claim 1 or Claim 2, wherein the impeller is an axial flow impeller.

9. A fluid flow indicator according to Claim 8 when appended to Claim 2, wherein the bar magnet is located within a cavity which is enclosed within the impeller adjacent one end of the impeller.

10. A fluid flow indicator according to Claim 8 when appended to Claim 2, or Claim 9, wherein the length of the bar magnet is small compared to the diameter of the impeller.

11. A fluid flow indicator according to Claim 8 when appended to Claim 2, or either of Claims 9 and 10, wherein the Wiegand effect device and the sensing coil are housed in a hollow rod which extends across the flow path so that fluid flows around the portion of the rod in which the device is housed.

12. A fluid flow indicator according to Claim 11 when appended to Claim 9, wherein the enclosed cavity is formed between a main body portion of the impeller and an insert which is fitted into a recess in the main body portion, the insert forming a conical projection on its outer surface and that conical projection being seated within a complementary recess which is formed in the outer surface of the hollow rod whereby to locate the impeller radially, the apex of the conical projection lying on the axis of rotation of the

impeller.

13. A fluid flow indicator substantially as described hereinbefore with reference to the accompanying drawings, and/or as shown in Figures 1 and 2 or in Figures 3 and 4 of the accompanying drawings.

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